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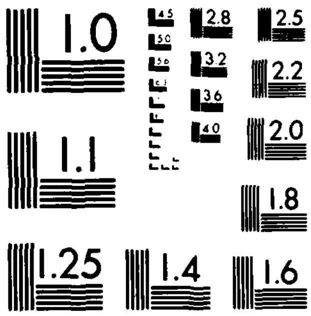
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The Naval Research Laboratory and the Naval Ocean Research and Development Activity plan to conduct a joint experiment during July and August, 1984, to investigate the variability of upper ocean properties on the fine-scale (10 m and smaller) in the vicinity of a front within the Subtropical Convergence Zone (30° 30' N, 71° W). A major goal is measuring the distribution of "patches" of intense variability and exploring their relationship to the front and the internal wave field. Initial mesoscale characterization of the experiment area will be based on multiple AXBT flights. Subsequent fine-scale measurements will involve a towed chain of temperature and conductivity sensors, a Doppler current profiler, a yo-yo CTD and velocity profiler, and a freely drifting thermistor chain.

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CONTENTS

PLANS FOR THE NRL/NORDA FINE-SCALE VARIABILITY EXPERIMENT — 1984 (FVX-84)

I. INTRODUCTION

This is the first in a series of research experiments investigating processes responsible for fine-scale fluctuations in the ocean. The experiment is to be a joint field effort involving NRL and NORDA using two ships (AGORs) and an aircraft in the area of the Subtropical Convergence Front, near 30° 30' N, 71° W, during July and August 1984. Primary goals are to obtain a multidimensional description of the fluctuation field and to test hypotheses concerning processes which produce fine and microstructure "patches"--discrete regions of energetic small-scale temperature and conductivity fluctuations. A working hypothesis is that the front will be a source of patches.

The Subtropical Convergence Front is described by Voorhis and Bruce (1982) as:

> "a long, narrow, boundary separating surface water masses of differing temperature, salinity, density, which can be tracked along the sea surface for 100 km or more. On the surface the width of the boundary is quite small, usually of the order of 100 m. Beneath the surface the boundary slopes downward under the lighter water mass and becomes level at depths of 50 to 150 m in a distance of the order of 10 km from the surface expression. One of the most important features of these fronts is the unusually intense surface jet which flows along the boundary in approximate geostrophic equilibrium with a cross-frontal pressure gradient set up by higher sea level on the less dense side of the front. Surface current speeds of 50 to 80 cm/sec are not unusual."

These features can be seen in Fig. 1, which shows the three-dimensional structure of the front as measured by Voorhis and Bruce. The lighter water mass is to the right, and the intense geostrophic flow is shown as a long vector parallel to the front; the smaller vectors show currents perpendicular to the frontal surface. This relatively simple picture is complicated by the presence of large-amplitude, transverse displacements of the frontal zone. For the Subtropical Front, these frontal meanders or "waves" have typical "wavelengths" of 50 km and amplitudes of 20 km. An example is shown in the lower half of Figure 1. The frontal waves generally propagate (at unknown speeds, for the Subtropical Front) along the front in the direction of the geostrophic along-front current (Garvine, 1983). The dynamics of the frontal waves is not geostrophic (Garvine, 1983; Voorhis and Bruce, 1982); nonlinear effects become increasingly important as the disturbances grow. The large-scale potential energy becomes degraded to smaller and smaller scales and converted to kinetic energy that is dissipated along deformed frontal boundaries.

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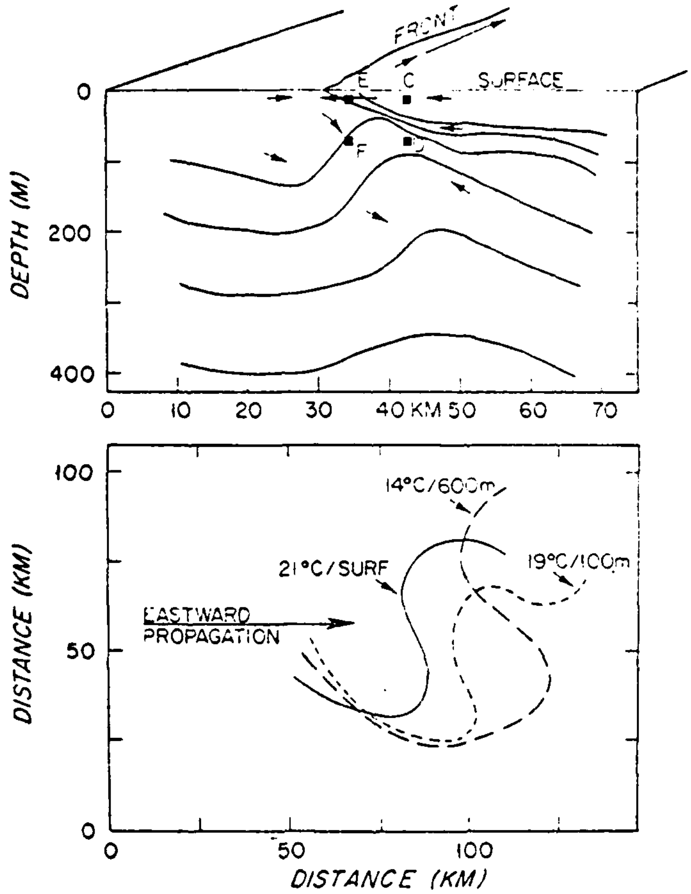


Fig. 1. Upper: Vertical temperature distribution across front on 15 March 1977 (contour interval is 1° C). Superimposed schematically, are the positions of drogues relative to front and current direction during frontogenesis.

Lower: Configuration of the 21, 19, and 14° C isotherms at the surface, 100 m, and 600 m, respectively. (From Voorhis and Bruce, 1982)

In the summertime, the Subtropical Front no longer has a strong temperature expression at the surface, but its other characteristics seem to remain similar to the more frequent wintertime observations. Figure 2 shows a cross-front temperature section made in July 1981 with NRL's towed thermistor chain; currents in the lighter water mass were as large as 30 cm s^{-1} as measured with NRL's Doppler current profiler (Trump et al, 1984). No large-scale mapping of the front was done at that time, but a large frontal meander was likely since the lighter, warmer water was encountered as the ship cruised northward.

Analysis of the temperature data from the serendipitous frontal crossing in 1981 is still underway (Marmorino, Dugan and Morris, in prep.), but it seems clear that in that one realization, the frontal zone is particularly rich in fine and small-scale structure. A few of the features seen (see Fig. 3) resemble Kelvin-Helmholtz "billow" turbulence as observed in laboratory experiments and in Loch Ness (Thorpe, et al, 1977); some events appear to be too wave-like to be mixing events; others are clearly intrusive in nature. The largest microstructure patches (measured with conductivity "needle" probes) also occurred in the frontal zone. All this makes sense since the large vertical shears there tend to make the water dynamically unstable. Trump et al (1984) show that, indeed, Richardson numbers are lowest and near critical values along the zone of maximum shear. Thus, the "climatology" of fine-structure patches is likely to be quite different near the front than elsewhere. Again, because of the strong shear, it is expected that the internal wave field will undergo changes in the frontal zone as well. Perhaps, absorption of internal wave energy at critical layers may result in a distribution of patchiness that is not so directly related to shear as in the case of directly shear-driven events. To begin to address these questions, a more systematic sampling of the front must be carried out. Furthermore, in order to better interpret the small-scale observations, it will be necessary to measure in some detail the structure of the frontal zone, the internal wave field, and their interaction.

The plan is to make further measurements in the 1981 area (Fig. 4). Additional details of the kind of environment to expect can be found in Trump et al (1984) and in Appendix A of this report. The basic instrumentation is unchanged from the earlier work: NRL's towed chain and Doppler current profiler. In addition, NORDA will use their VCTD (Velocity-Conductivity-Temperature-Depth) profiler from a separate ship to resolve the velocity structure on vertical scales smaller than are possible with the Doppler system and to provide vertical density profiles. The third component of the experiment is a series of four AXBT flights to locate and map the front, thus guiding the ship-based observations. Several changes in equipment are being made. NORDA will be using a new motion-compensating winch to handle the VCTD. NRL's towed chain with its motion compensation system will be used for the first time on a small AGOR. In addition, NRL will be using a newly modified configuration for its towed conductivity sensors; a new microprocessor-controlled, high-vertical-resolution mini-array of thermistors will be attached to the usual towed chain; and a new thermistor chain will be used separately as a

freely drifting instrument. Prior to any scientific experiments, these new systems will have to be thoroughly checked. Because of the unproven combination of sensors and systems, this 1984 experiment must be viewed as preliminary.

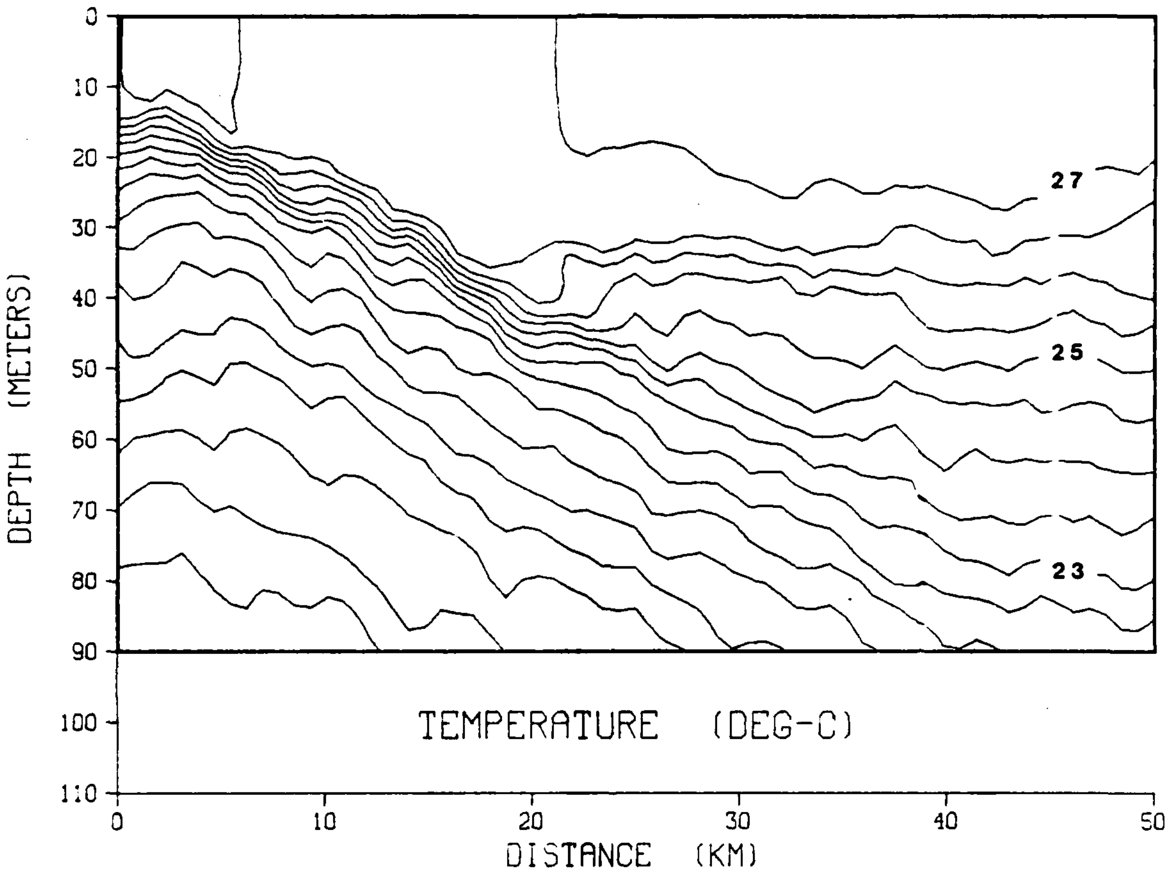


Fig. 2. Temperature coutours in 0.5° C increments along a northward track of the USNS Hayes on 20 July 1981 as it crossed the Subtropical Front. (From Trump et al, 1984.)

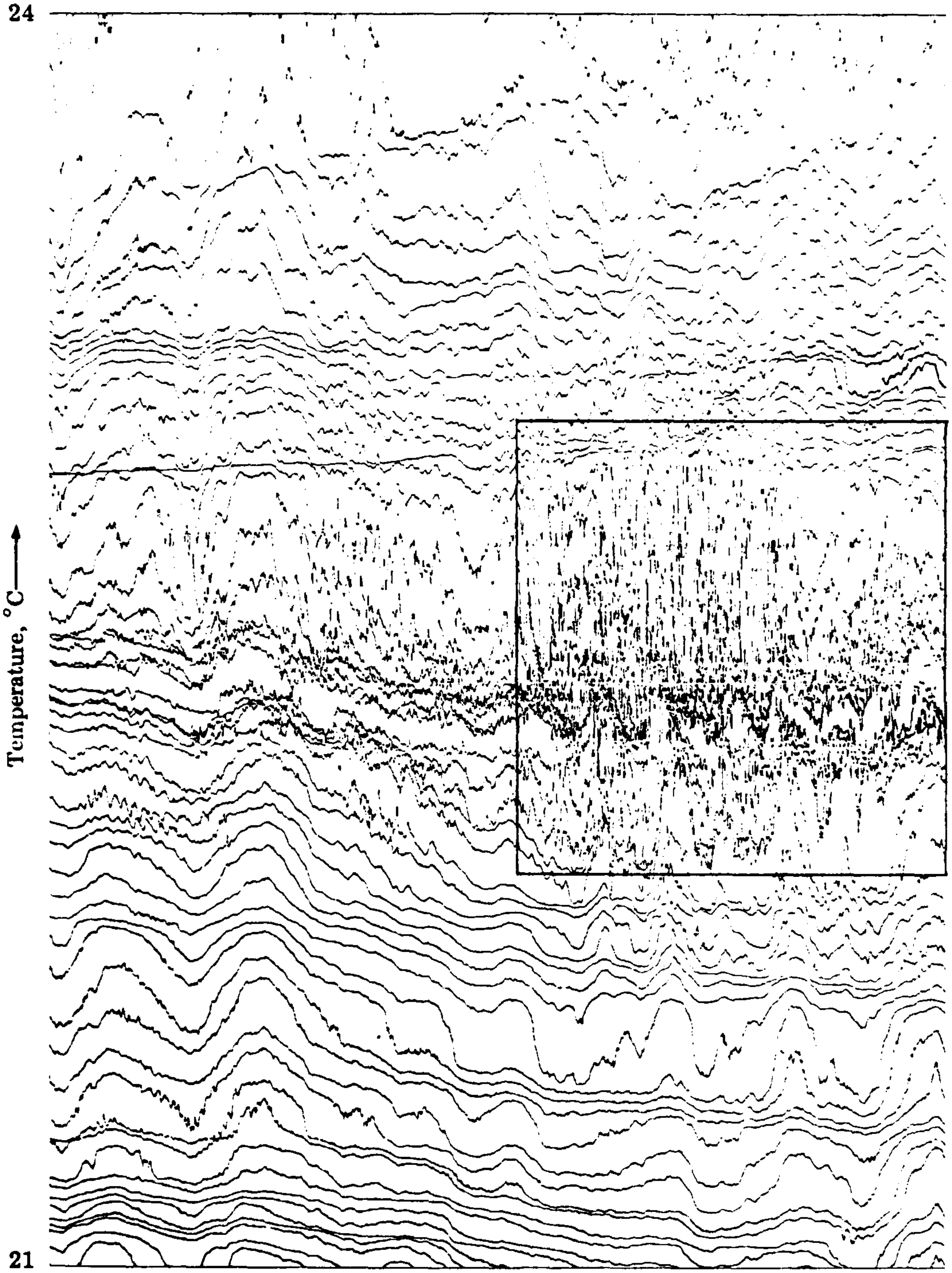


Fig. 3. Temperature time series from sensors in the seasonal thermocline. The region in the box is one of the most active signal bursts seen in the 1981 data set. A series of 3 or 4 well-mixed regions (where the traces overlap) alternating with large-gradient regions is the characteristic signature of a train of Kelvin-Helmholtz-like flow instabilities.

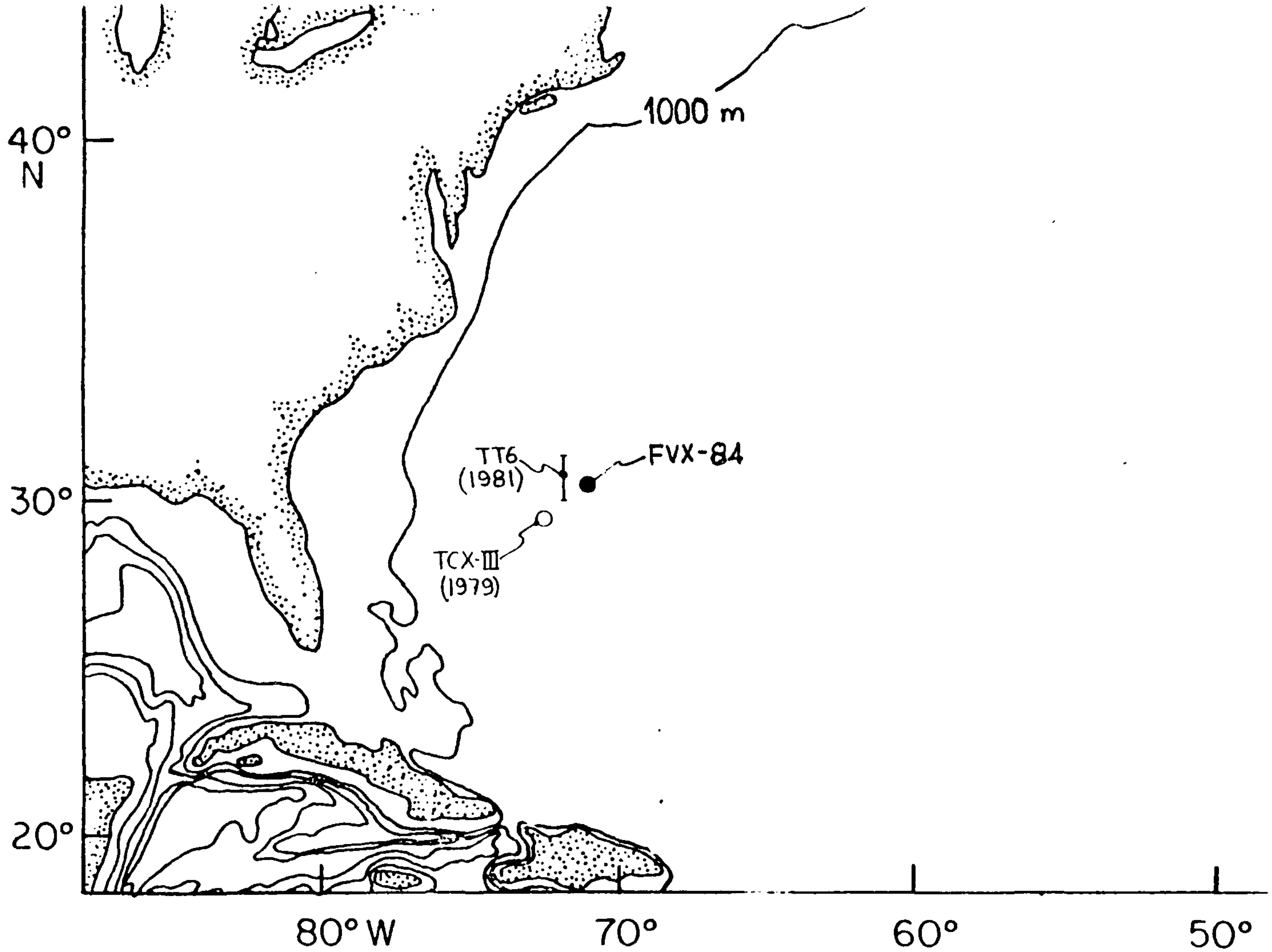


Fig. 4. Location of experiment. Also shown are locations of past experiments.

II. SCIENTIFIC OBJECTIVES

In approximate order of decreasing emphasis, these are summarized as follows:

(1) Patch climatology. Determine the spatial distribution of patches, with emphasis on their relationship to the frontal and to internal wave variability.

(2) Patch morphology. Measure the detailed structure of a patch. Is there active mixing occurring in the patch? Can we estimate (at least) a lower bound on the energy dissipation in a patch? Do large patches appear similar to smaller ones? Can any particular process--Kelvin Helmholtz billows, internal wave overturning, double-diffusive convection--be identified as a cause of a patch?

(3) Internal wave variability. What is the relationship of the internal wave field to the front? Are waves generated locally by the wind or surface waves? What is the period of the dominant first-mode waves? Are they somehow guided by the frontal surfaces? Can the directionality of individual wave groups be observed?

(4) Layers. What is the cause of the "layer and sheet" or "stepped" structure of the seasonal thermocline? Are the layers related to internal-inertial waves? Is the shear across the layers large enough to provide local stirring? Are they uniform in temperature and salinity?

(5) Frontal configuration. What is the large-scale structure of the piece of the Subtropical Convergence Front under observation?

III. DESCRIPTION OF RESEARCH EQUIPMENT AND PLATFORMS

An aircraft and two small AGORs (USNS LYNCH and USNS BARTLETT) will make the coordinated measurements for the experiment. All research equipment will be tested in an area off the Virginia Capes prior to proceeding to the operating area for the experiment.

NRL P-3 Aircraft

The AXBT flights will use one of the NRL P-3 aircraft from the Patuxent River Naval Air Station, Maryland. Approximately 80 AXBTs will be dropped during each of four flights. (See Section V for details.)

USNS LYNCH

The following equipment will be on the USNS LYNCH:

1. NORDA's VCTD Profiler with motion-compensating winch. This instrument is a CTD combined with a 3-axis acoustic current meter. Casts are made while the ship is making some way (about 1 knot). A lowering speed in the range 20-60 m min^{-1} is chosen to provide a resultant velocity vector oriented at about 45° to the instrument. Three casts are usually made per station, data being collected on down casts only. The instrument's depth limit is 300 m; and station time is estimated as 1 h. The CTD uses a 3 cm cell, a 100 ms response thermistor, and a 16 sample-per-sec data rate (vertical resolution is, thus, better than 6 cm). Data will be recorded on an HP9825. Time plots with only a coarse (every sixth point) resolution may be available at sea. Results of testing the velocity sensors in a tow tank are described by Perkins et al (1980). Figure 5 shows the arrangement of the velocity and CTD sensors.

2. Expendable shear (dissipation) probes. These will be the Osborn aerofoil type, capable of measuring the vertical shear of the horizontal current on scales of 1 m to 1 cm. An estimate of the dissipation of kinetic energy can be computed from the shears. Twelve of these will be available. A deck unit (on loan from T. Osborn) and Zenith micro-computer are used for data logging.

3. NRL's Drifting Thermistor Chain. A freely-drifting array of 14 thermistors having vertical aperture of 75 m will be located below the surface mixed-layer. A pressure sensor and digital data logger will be located at the bottom of the chain. A spar buoy will provide surface flotation. Some further details may be found in Appendix B.

4. NORDA drogues. Surface float tied with 100-lb-test fishing line to a mylar "sail" at depth. These are to be deployed during patch morphology studies.

5. Miscellaneous. XBT, communication, and navigation instrumentation. A standard CTD will be available as backup for the VCTD.

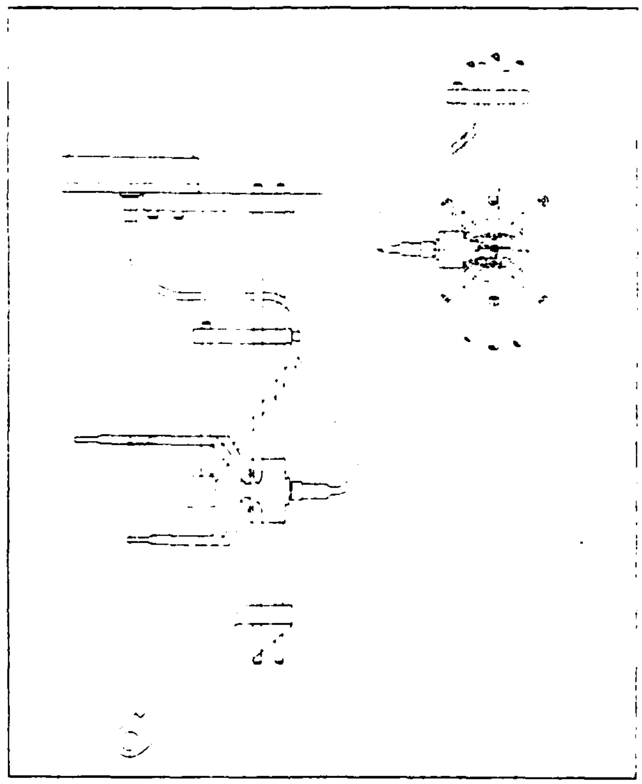


Fig. 5. Partial view of the NORDA instrument as seen from the side (on the left) and from the front (on the right) showing the arrangement of the velocity and CTD sensors.

USNS BARTLETT

The following will be on the USNS BARTLETT:

1. NRL Doppler Current Profiler (Amatek-Straza DCP 4400). Measurements are made between depths of 10 and 120 m, with resolutions of 5 m in the vertical and 200 m in the horizontal. Currents averaged for 1 min are resolved to 1.5 cm s^{-1}. An HP 1000 computer will be used for data recording, real-time processing, and display.

2. NRL Towed Chain (see Fig. 6). The chain has 180 thermistors spaced every 0.5 m over a vertical aperture of 90 m. Eight Neil Brown four-electrode conductivity sensors will be attached to the array at eight of 11 four-pin breakouts located at 2.5 m intervals along a 25 m section (45 - 70 m depth). At the usual tow speed of 5 knots, the horizontal resolution of the measurements is ~ 1.5 cm for conductivity and ~ 0.5 m for temperature. Tow speeds less than 5 knots are possible under certain conditions and would increase the horizontal resolution. The Towed Chain of temperature sensors, its performance, and data displays, has been described by Morris et al (1983).

An on-deck conductivity station using Sea-Bird flow-through cells will be used for two purposes. First, it will serve to check the calibration of the Neil Brown sensors before and after each tow. This is essential if salinity and density are to be reliably computed. Second, during towing, water from an instrument well will be pumped to the station, providing a continuous record of near-surface conductivity and temperature. Salinity calculated from these data will help to identify any near-surface expression of the front.

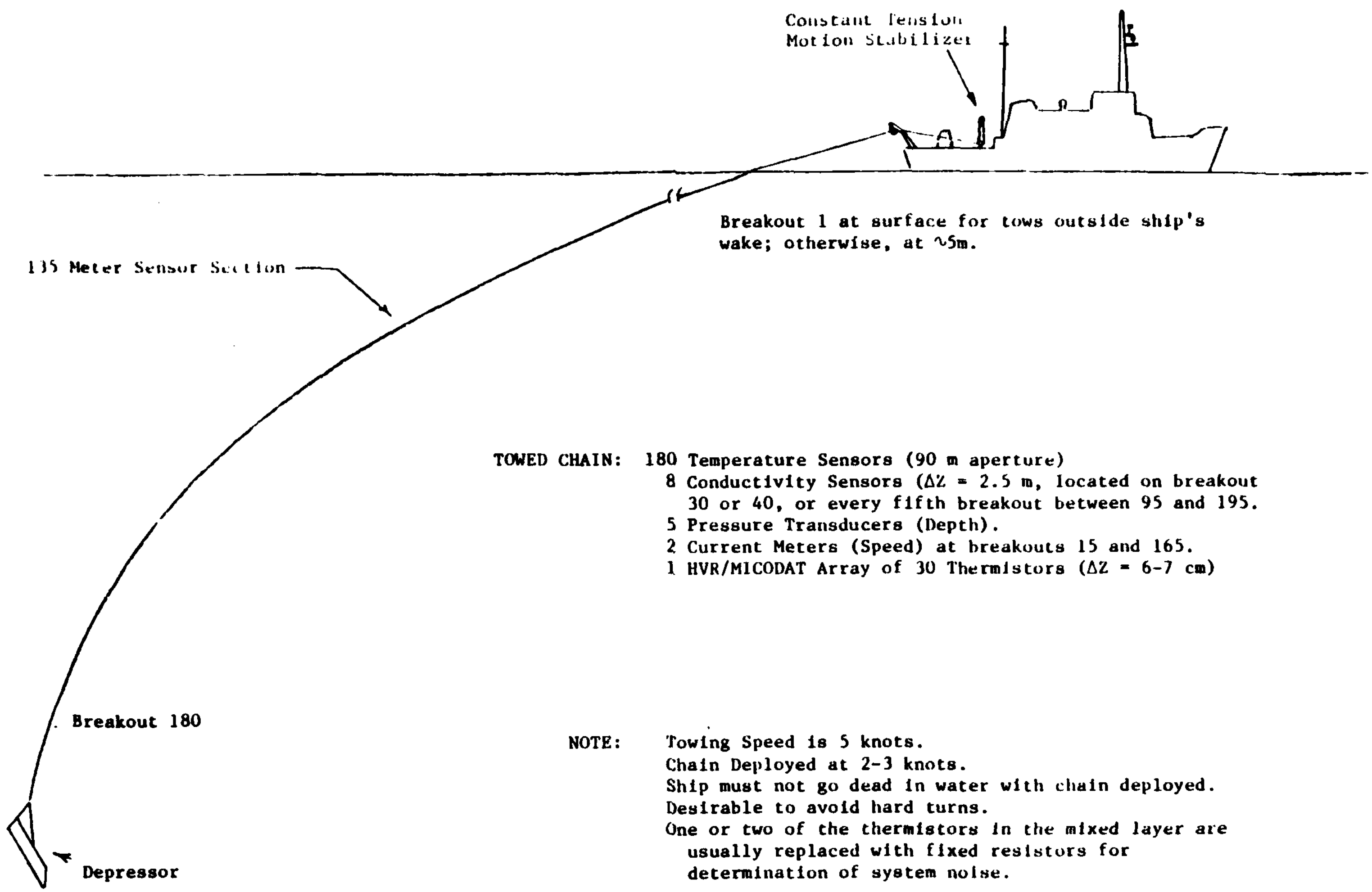
There will also be an autonomous 3-m-long array with 30 thermistors spaced 10 cm apart (6-7 cm in the vertical). Data from this High Vertical resolution (HVR) array is interfaced with an NRL designed Microprocessor-Controlled Data Acquisition and Telemetry System (MICODAT) and sent digitally up one of the shielded four-pin breakouts. The HVR/MICODAT will be located either in the mixed layer or in the 25-m section of the towed array.

Four Data General Eclipse computers will provide for acquisition of the chain data, tests of data quality, processing for real-time display and analysis, and some off-line processing for later analysis.

3. General environmental measurements

Near-surface temperature, conductivity, meteorological variables, location, and ship-operating characteristics (see Table 1) will be recorded on the HP 1000.

4. Miscellaneous. Navigation (LORAN real-time track plot plus computer tapes) and communication instrumentation. A standard CTD will also be available.



TOWED CHAIN: 180 Temperature Sensors (90 m aperture)
8 Conductivity Sensors (ΔZ = 2.5 m, located on breakout 30 or 40, or every fifth breakout between 95 and 195.
5 Pressure Transducers (Depth).
2 Current Meters (Speed) at breakouts 15 and 165.
1 HVR/MICODAT Array of 30 Thermistors (ΔZ = 6-7 cm)

NOTE: Towing Speed is 5 knots.
Chain Deployed at 2-3 knots.
Ship must not go dead in water with chain deployed.
Desirable to avoid hard turns.
One or two of the thermistors in the mixed layer are usually replaced with fixed resistors for determination of system noise.

Fig. 6 — NRL's towed chain

Table 1. General environmental measurements

Variable	Number of Systems/Sensors	Resolution	Sensor Type
Air Temp.	2	0.01°C	Platinum thermometer/ Thermistor
Dew Point	2	0.01°C	Chilled mirror
Wind Speed	2	0.1 kt	Cup Anemometer
Wind direction	2	1°	Vane
Water Temp.	1	---	Frequency Bridge/Thermistor
Water Conductivity	1	---	Frequency Bridge/cell
Global Irradiance	1	1 W/m^2	Black & White Pyranometer
Ship Roll Angle	1	0.01°	Pendulumm Inclinometer
Rudder Angle	1	1°	Synchro
Heading	1	1°	Synchro
Screw RPM	1	1 rpm	Synchro
Latitude	1	0.01'	LORAN C
Longitude	1	0.01'	LORAN C
Ship Speed	1	0.1 m/sec	LORAN C
Ship Course	1	1°	LORAN C

IV. RESEARCH RESPONSIBILITIES

Responsibility	Purpose
NRL:	
Towed Chain (USNS BARTLETT)	Patches
Temperature Sensors	Fine structure/internal waves
Conductivity/temperature sensors	Density computations
Conductivity Sensors	Microstructure and patches
High-vertical resolution temperature sensors	Measurements at 10 cm vertical spacing
Doppler Current Profiler (USNS BARTLETT)	Velocity structure
Drifting Thermistor Chain (USNS LYNCH)	Temporal internal wave characteristics
AXBT Flights (NRL P-3)	Area characterization
On-board real-time and quick look data processing (USNS BARTLETT)	Experiment feedback and results
Navigation Control(USNS BARTLETT)	Experiment control
NORDA:	
VCTD (USNS LYNCH)	Temporal characteristics of: water column density internal waves inertial waves
Navigation control (USNS LYNCH)	Experiment control
Drogues to mark water in vicinity of patch	
Dissipation Probes	Dissipation-scale turbulent signals

V. EXPERIMENT

The experiment includes four AXBT (Aircraft Expendable Bathythermograph) flights, an equipment test period, and three phases of ship-board measurements (separated by two service periods). The AXBT flights will be made to locate and map the front. (Satellite imagery is useless during the summer because of the small differences in surface temperature across the front.) Between the second and last flights, the ship-based measurements will be made. The Towed Chain will be deployed for about three days during each of three phases. Phase 1 will be a large-scale mapping of the front, while Phases 2 and 3 will involve sampling patterns of a more local nature. The Doppler Current Profiler will be used continuously. The Drifting Chain will be deployed only in Phases 2 and 3. In addition to its use at other times, the VCTD will be used for intensive profiling while the Towed Chain is being refurbished.

AXBT Flight 1

This first flight will be made in advance of any ship operations. It will cover a 3° X 3° area centered at 30° 30' N, 71°W, with about 80 deep AXBTs. (A deep AXBT measures temperature to a depth of 760 m; a shallow one to 380 m.) Contour maps of these data will be examined for the presence of the front as well as for any features (such as eddies) that are to be avoided during the experiment.

Instrument and Systems Testing

Tests of all ship-based research equipment and systems will be made in an area off the Virginia Capes, only a half-day's travel from Norfolk.

AXBT Flight 2

This flight will occur towards the end of the testing period. It will relocate and map the front in some detail. A grid-spacing of about 15 km is planned, with mostly shallow AXBTs being used except at the ends of each north and south leg where deep AXBTs will be used. This same scheme will be used for later flights as well.

Phase 1

This will be a large-scale mapping of the front. The ships will cross the front at regularly-spaced intervals in a continuous, along-front, zig-zag pattern. Each time the frontal zone is encountered, the ship's gyro heading will be kept fixed for the remainder of that leg. Since the frontal zone is likely to be 30-40 km wide, each leg of the pattern will need to be about 70 km long. (One leg, probably the first, should be long enough to measure the horizontal e-folding scale of the along-front flow.) At a tow speed of 5 knots (about 10 km h^{-1}), the complete pattern will consist of about 10 legs.

The NORDA ship (LYNCH) will follow along the same track, slowing periodically to make VCTD stations, then speeding ahead to maintain an average forward speed of 5 knots to keep up with the BARTLETT. In this way, four VCTD stations can be made per leg. An alternative plan here is to increase the horizontal sampling by making a single cast at more

closely spaced stations. (A spacing of 1-2 km in the maximum shear zone, 5 km elsewhere, would be good; and even a standard CTD could be used.) This sacrificing of the small-scale velocity information at this time would permit a much more detailed measurement of the density field from which better estimates of the geostrophic current can be calculated. This would better determine those places along the front where significant deviations from geostrophic balance occur; and it is conjectured that these regions of ageostrophy may be more favorable sites for small scale dynamic instability and the creation of patches. It is, in fact, because of the belief that the patch climatology varies along the front (because of changes in the balance of forces) that this survey phase is being undertaken.

After eight or so legs, the ships will reverse the sampling direction, moving westward for the remaining legs. In this way, both ships will be closer to the center of the sampled part of the front at the beginning of the next phase.

Phase 1 will end with the BARTLETT locating a likely region for patches so the LYNCH can set out a float drogued to an appropriate depth. This is not going to be easy to do: for one thing, ~ 5 min elapse before a view of the Towed Chain data becomes available; and by the time a decision is made as to the suitability of the event the BARTLETT might be a kilometer or more from the right spot (at 5 knots, 7 min ~ 1 km). The procedure we plan to adopt is as follows: A detailed search for patches will be conducted in the zone of maximum shear (where the Richardson number is lowest). A likely area will have been identified when patches are found in roughly the same place in at least two successive tows. Additional tows (made at lower speeds, if possible) will permit surface markers to be cast out from the BARTLETT to "mark the spot" for the LYNCH. Meanwhile, the appropriate depth will have been more exactly determined (some special processing must be done for this) and relayed to the LYNCH.

First Service Period (24 h Station)

The LYNCH follows the drogued patch, making frequent VCTD profiles. At 30°N, the inertial period is 24 h, so the profiling will continue for a full 24 h.

The Towed Chain is retrieved. Conductivity sensors are cleaned and their calibration checked. Faulty thermistors and worn shackles are replaced. Once the chain is aboard, the BARTLETT will relocate an interesting feature (probably, a warm water intrusion at the base of the surface mixed layer) and do intensive CTD profiling. The BARTLETT will then relocate itself in the front, near the LYNCH.

Phase 2 and AXBT Flight 3

The BARTLETT will redeploy the chain and locate the zone of maximum frontal shear. The LYNCH will then deploy the Drifting Chain and begin a 30 h VCTD station nearby. The times of VCTD profiles will be coordinated with the nearby passage of the BARTLETT which will be towing in an approximate star-shaped grid, 10 km in diameter centered about the LYNCH. Care will have to be taken to avoid sampling the wake of the towed cable. This scheme makes possible the following:

1. Frequent conductivity comparisons between VCTD and Towed Chain.
2. Determination of the propagation direction of internal waves via Doppler shifting. (This would work especially well if the same group of waves is sampled on repeated tows.)
3. Simultaneous measurement of an internal wave group using all sensor systems.
4. Correlation between VCTD and Towed Chain measurements of layered structure.
5. Calculation of spatial derivatives about the center of the pattern.
6. Use of the dissipation probes at times when the Towed Chain identifies patches close to the LYNCH.
7. Repeated tows parallel to and perpendicular to the front so that billow-like events (presumably oriented across the flow) can be sampled along orthogonal directions.
8. Repeated tows at various orientations to the wind so that shear-induced structures in the mixed layer can be better identified.

AXBT Flight 3 will take place during this phase. Besides dropping the AXBTs, a chance may present itself to do some limited coordinated aircraft-ship sampling. For example, an observer on the aircraft may be able to direct (via bearing and distance) the BARTLETT to a distinct, nearby foam line which can be sampled for a short time. At the very least, pictures can be taken from the aircraft of the ships, ship wakes, cellular patterns on the ocean surface, etc. To be of maximum benefit to the experiment, each frame shot should contain time information, the time being synchronized with that used on the ships.

A second 30 h period of VCTD profiling and star-pattern towing in the front is planned for the remainder of Phase 2.

Second Service Period (24 h Station)

This would be similar to the first service period.

Phase 3

Again, two 30 h periods of VCTD profiling and towing are planned, but now in locations away from the front where the vertical shear is small and the occurrence of patches is expected to be less frequent. The first will be ~ 50 km south of the front; the second, ~ 50 km north. Since the same grid pattern will be used for all the 30 h stations, statistics related to patches and internal waves will be gathered in the same systematic fashion, making later comparisons of results much more straightforward.

AXBT Flight 4

This final flight will be a repeat of Flights 2 and 3, and will occur soon after Phase 3.

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VII. EXPERIMENT SCHEDULE

19 Jul 84	Area Characterization	AXBT Flight 1
18-25 Jul 84	Load BARTLETT	BARTLETT dockside
25 Jul 84	Transit to VACAPES area	BARTLETT underway for experiment
23-26 Jul 84	Load LYNCH	LYNCH dockside
26-31 Jul 84	Research Equipment tests	BARTLETT, vicinity of VACAPES
29-31 Jul 84	Research Equipment tests	Coord. Tests of LYNCH & BARTLETT
30 Jul 84	Area Characterization	AXBT Flight 2
31 Jul-1 Aug 84	Transit to Experiment area	LYNCH & BARTLETT underway
1-12 Aug 84	Experiment--Vicinity of 30° N 70° W	Coord. Ops-LYNCH & BARTLETT
6 Aug 84	Area Characterization	AXBT Flight 3
13 Aug 84	Area Characterization	AXBT Flight 4
13-15 Aug 84	Transit to port	LYNCH & BARTLETT underway
16-17 Aug 84	Unload ships	LYNCH & BARTLETT

APPENDIX A: Further Details of the Measurement Site.

Figure A1 is a reproduction of the deck log from the USNS HAYES during the time (0025-0550 local) of the front crossing shown in Fig. 2. It shows what weather conditions can be expected for the planned experiments.

Figure A2 shows profiles of temperature, salinity, buoyancy frequency, and conductivity from the 1981 cruise. The surface mixed layer can be seen to be about 20 m thick; the seasonal thermocline extends to about 100 m where it joins 18°C water. Salinity varies little; as a result, the vertical distributions of density and conductivity are primarily determined by temperature.

SHIP'S DECK LOG

MSC FORM 3211/6 (REV. 2-71) S/N 0106-LF-137-3601

DATA SHEET

SHIP	VOYAGE NUMBER	DATE
USNS HAYES T-AGOR 14	53	JULY 20, 1981
PASSAGE (At ~~or from~~) OPSAREA — TO		DAY OF WEEK MONDAY
ZONE DESCRIPTION +4	CHANGED AT (Time) — TO	

HOURS (1)	RPM (2)	GYRO READING (3)	GYRO ERROR (4)	TRUE HEADING (5)	MAG STD (6)	MAG STG (7)	VARIATION (8)	DEVIATION (9)	ERROR (10)	WIND DIRECTION (TRUE) (11)	WIND SPEED (KNOTS) (12)	VISIBILITY (MILES) (13)	WEATHER (SYMBOLS) (14)	BAROMETER (MILLIBARS) (15)	DRY BULB (16)	WET BULB (17)	SEA WATER INJ (18)	CLOUDS AMOUNT (TENTHS) (19)	CLOUDS HEIGHT (FEET) (20)	CLOUDS TYPE (21)	WAVES DIRECTION (TRUE) (22)	WAVES HEIGHT (FEET) (23)	SWELL DIRECTION (TRUE) (24)	SWELL HEIGHT (FEET) (25)
01																								
02		000	0	000	010		9W	1W	10W	210	12	12	1	1018	80	77		3	8000	AC	210	2	260	5
03																								
04		000	0	000	010		9W	1W	10W	210	12	12	1	1018	81	78	78	3	8000	AC	210	2	260	5
05																								
06		000	0	000	010		9W	1W	10W	220	12	12	1	1018.0	80	78		4	2000	Cu/Cu	220	1	260	5
07																								
08		000	0	000	010		9W	1W	10W	220	14	12	2	1018.3	88	73	79	5	2000	Cu	230	2	270	5
09																								
10		000	0	000	010		9W	1W	10W	230	8	14	2	1018.5	94	87		5	2000	CU	230	2	270	4
11																								
12		180	0	180	190		9W	1W	10W	230	15	14		1018.5	86	70	79	5	2000	CU	230	2	240	4
13																								
14		180	0	180	190		9W	1W	10W	230	15	15	1	1018	89	78		3	3000	CU	230	2	240	4
15																								
16		165	0	165	175		9W	1W	10W	230	15	15	1	1018	87	82	79	3	3000	CU	230	2	230	4
17																								
18		165	0	165	175		9W	1W	10W	220	12	12	2	1017.5	87	82		5	1500	SC/Cu	220	1	250	5

Fig. A1 — Deck log showing expected conditions for planned experiment.

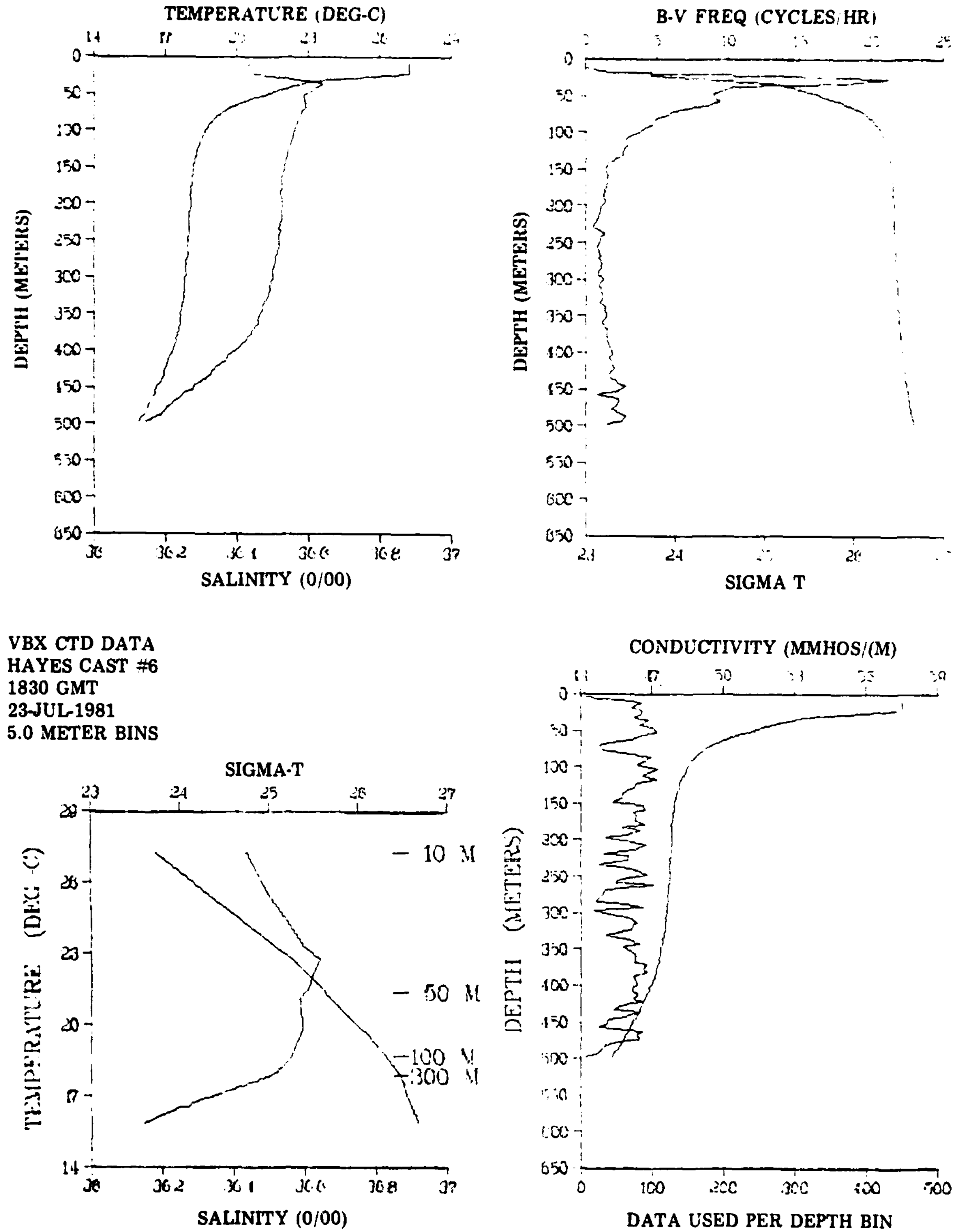


Fig. A2 — Water properties in the experimental area.

APPENDIX B: Drifting Thermistor Chain Data Acquisition

A full Verbatim T-450 casette tape in the SEA DATA 650-6 FTD Data Logger consists of 60,000 records or scans. Deployment time depends on scan interval as follows:

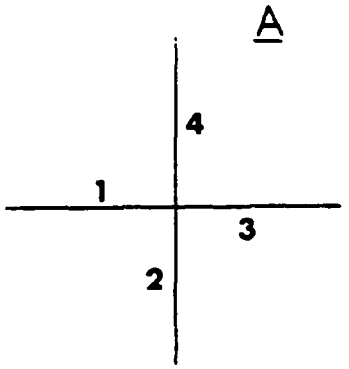
DEPLOYMENT DAYS/HRS		SCAN INTERVAL (SEC)
	16.7	1
1	9	2
2	19	4
5	13	8
11	3	16
22	5	32

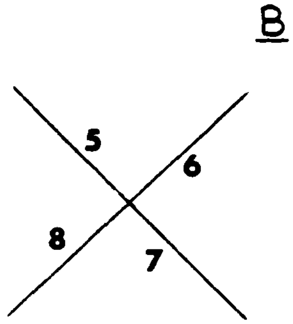
During the test phase, a scan interval of 1 sec will be used in each of several short deployments. During the experiment, a 2-sec scan interval will be used in each of four 30-h deployments. Since the time constant of the thermistors on this chain is 6-8 sec, a 2-sec sampling should be adequate to prevent aliasing.

APPENDIX C: Survey Pattern for Phase 2 of the FVX Experiment - 84

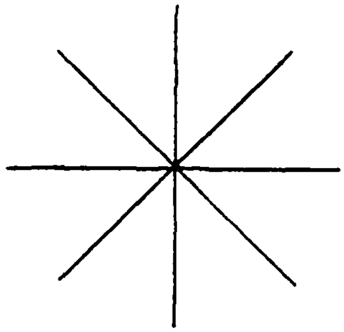
In the experimental plan, eight types of measurements are listed for Phase 2 of the experiment. To make types 2 and 5 measurements, namely internal wave propagation and spatial derivatives of Reynolds stresses, a particular sampling pattern is required. The following pattern is planned; it satisfies the other types of measurements in the plan as well.

Survey patterns:





Pattern B is a 45° rotation of A, to extend the angular range of the sampling. Both patterns share a common center, so their composite pattern is



The above patterns allow estimation of horizontal spatial derivatives in two orthogonal directions as well as wave propagations in two orthogonal directions.

Each of the eight tracks in the above "star" pattern is to be surveyed from the star center, outward to the tip and then back to the center. This double sampling allows estimation of the phase speed and propogation direction of the dominant internal wave group. The propagation information will be useful additionally for adjustment of the measurements to remove the doppler shift that can cause error in the spatial derivative estimation.

DATE
ILME